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MOßSBAUER STUDIES OF Fe²⁺ AND Fe³⁺ MIXED STATE IN ILMENITE-HEMATITE SOLID SOLUTION

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Recently, the doping of corundum-related \( \alpha \)-Fe\(_2\)O\(_3\) has very attracted interest because of room-temperature magnetic semiconductor for spintronics materials.[1,2] Both ilmenite, FeTiO\(_3\) and hematite, \( \alpha \)-Fe\(_2\)O\(_3\), have the rhombohedral structure. \( \alpha \)-Fe\(_2\)O\(_3\) can be visualized as consisting of layers of Fe ions in the (111) planes with oxygen layers between them. The structure of FeTiO\(_3\) can be derived from that of \( \alpha \)-Fe\(_2\)O\(_3\) by replacing every other layer of Fe ions by a layer of Ti ions. The both compounds, Fe spins are parallel within a given (111) plane and antiparallel between adjacent planes showing antiferromagnetism. The 0.9FeTiO\(_3\)-0.1Fe\(_2\)O\(_3\) solid solution were prepared by solid state reaction with FeTiO\(_3\) and \( \alpha \)-Fe\(_2\)O\(_3\) powders, and studied by x-ray diffraction, Mössbauer spectroscopy, and vibrating sample magnetometer (VSM). The examination of these solid solution by Mössbauer effect in \(^{57}\)Fe gives new information concerning the magnetic as well as chemical environment. The crystalline structure was found to be single phase rhombohedral structure with lattice constants \( a = 5.089 \, \text{Å} \) and \( c = 14.051 \, \text{Å} \). Mössbauer spectra of 0.9FeTiO\(_3\)-0.1Fe\(_2\)O\(_3\) solid solution were taken at various temperature ranging from 4.5 to 295 K. The anomalous absorption curves are observed. For 0.9FeTiO\(_3\)-0.1Fe\(_2\)O\(_3\) solid solution sample, the Mössbauer spectra at 4.5 K was fitted to three six-line hyperfine pattern with magnetic hyperfine fields \( H_{hf} = 498, 379, \) and 202 kOe, respectively. Above 50 K, the spectrum show asymmetry two-line pattern. The fitted curves at room temperature are obtained by superimposing two doublet, the one corresponding to Fe\(^{2+}\) and the other to Fe\(^{3+}\). The isomer shift \( \delta \) and quadrupole splitting \( \Delta E_Q \) of 0.9FeTiO\(_3\)-0.1Fe\(_2\)O\(_3\) solid solution is 0.92, 0.14 mm/s and - 0.69, - 0.29 mm/s, respectively as expected for Fe\(^{2+}\) and Fe\(^{3+}\). Corresponding relative absorption subspectral areas are 89.2 % for Fe\(^{2+}\) and 10.8 % for Fe\(^{3+}\). The temperature dependence of the magnetization taken in zero-field-cooling (ZFC) and field-cooling (FC) condition of the 0.9FeTiO\(_3\)-0.1Fe\(_2\)O\(_3\) sample exhibits no great irreversibility between ZFC and FC magnetization. Magnetization measurements indicate ferromagnetic behavior with 92 Oe coercivity value at 50 K but at 300 K show no hysteresis loop. The magnetic Néel temperature \( (T_N) \) was determined to be 98 K by zero field cooled magnetization curves under the 100 Oe applied field. From these results, it is considered that some kind of ferromagnetic small clusters created by incomplete chemical order in 0.9FeTiO\(_3\)-0.1Fe\(_2\)O\(_3\) solid solution exist.